6. Bearing Temperatures

6.1 Admissible Bearing Temperatures

Considering the operating life of lubricating oils and the heat resistance of white metals we make the following suggestions for admissible temperatures of our bearings:

a) measurements with standard thermoprobes in the oil flow or respectively in the oil bath:

T_{lim} = 80°C

b) measurement with standard thermoprobes in the loaded zone of the bearing shell:

T_{lim} = 90°C

c) measurements with good-quality thermoprobes which are carefully built in and have metallic contact for certain with the bearing shell in the loaded zone:

T_{lim} = 110°C

d) precise measurements with resistance thermometers (possibly also with thermocouples or other measuring instruments) in approx. 1...3 mm distance from the bond compound surface steel/whitemetal in the zone of maximum temperature:

T_{lim} = 125°C

If, due to hydrodynamic calculation, the peak temperatures are to be expected higher than 125°C bearing metals and lubricating oils should be carefully selected. In that case for bearings with high loadings and high speeds temperatures of up to

T_{lim} = 150°C

may be allowed.

If Installation or Survey Instructions or specific guidelines state maximum admissibe temperatures the relevant measuring points have to be considered.

Extremely low admissible bearing temperatures – as sometimes required – often result from measurements in the oil sump or at the oil outlet and cannot be compared with the temperatures taken in the loaded zone of the bearing.

6.2 Alarm and Shut-Down Temperatures

Basis for the initial setting of alarm and shut-down temperatures is the calculated operating temperature. However this calculation of operating temperature must take into consideration the highest possible site ambient, and/or oil inlet temperature, as well as the maximum speed and relevant loadings.

The alarm temperature should be set 10 K higher than the calculated bearing temperature and the shut-down-temperature approx. 20 K higher.

If, after start-up of the machine, the actual bearing temperatures are considerably higher than those calculated (e.g. by heat transfer to the bearings), the measured values will serve as the new basis for setting the alarm and shut-down temperatures, this however, only after having consulted RENK. The values should be rounded off to figures ending in 5s or 10s.

6.3 Temperature Measurements

Generally the following types of temperature measurement are used in engineering:

6.3.1 Measurements Using Liquid-Filled Thermometers

6.3.1.1 Bar and angle thermometers facilitating direct reading of the liquid column along a linear scale.

6.3.1.2 Needle thermometers, where the expansion of the liquid pressurises a Bourdon tube and where the expansion is transmitted to the shaft of the thermometer by means of a pinion.

Where a heat sensor and display unit are fitted separately, they are linked by means of a capillary tube. This must never be opened up, since it forms an integral part of the system.

6.3.2 Measurement using Electrical Thermometers

6.3.2.1 Thermocouples, as the name indicates, are elements, where the soldered junction of two wires made from different materials produces a voltage, the magnitude of which depends on the temperature, where this voltage can be read using a voltmeter calibrated in temperature units.

The advantage of thermocouples is that they are very small and that they are suitable for very high temperatures; their disadvantage is the larger measuring error compared with resistance thermometers and the need to use so-called compensated leads between thermocouples and measuring instruments, which must be made from the same materials as the thermocouple itself, since the junctions would otherwise represent another thermocouple in itself. Compensate leads can only be avoided if a measuring transducer is fitted directly to the thermocouple. Thermocouples age and change their measuring characteristics. This ageing cannot be predicted.

Resistance thermometers are frequently used, and for this reason they will be dealt with in detail here.

Since these are electrical or electronic methods, the description which follows – which is not intended to be scientifically accurate – is meant for easy understanding and relates specifically to the Pt 100 sensors in use in Europe.

The principle of temperature measuring using resistance thermometers is based on the measurement of the electrical resistance of a measuring resistance in the temperature sensor. The electrical resistance is a function of temperature i.e. the temperature-dependent change of the electrical resistance of the conductor (measuring resistor) is used for the determination of the temperature.

Materials with a large temperature coefficient are used for a measuring resistor. In addition great care is taken to ensure that the materials do not age in the temperature range in which they are used. For this reason platinum (Pt 100) is mainly used. „100" means that this measuring resistance has a resistance of 100 Ohms (Ω) at a temperature of 0°C.

In accordance with DIN 43760 there must be a resistance ratio of $R_{100}/R_0 = 1{,}385$, i.e. at 100°C the resistance is 138,5 Ohms.

The characteristics curve of the measuring resistance is defined in accordance with the equation:

$$R_T = 100\,(1 + 3{,}90802 \cdot 10^{-3}\,T - 0{,}580195 \cdot 10^{-6} \cdot T^2)$$

where R_T [Ω] is the resistance at temperature T [°C].

For the display unit it is also possible to provide a digital display with LED (illuminated) or LCD (dark).

A more elaborate version of the display is the regulator (fig. 31). A regulator (generally an electronic unit) can be designed as a single, two or three point regulator. It is then possible to use these points as switching points. They actuate a limit switch once the set temperature has been reached. This contact can be used for any signalling and regulating purpose.

Some regulators are also provided with an output to which a temperature chart recorder can be connected.

It is possible to have a 2, 3 or 4-wire circuit between the temperature sensor and the display or regulator, in accordance with the circuit diagrams given on our type sheets.

To be able to use our standard thermoprobes the 3 and 4-wire circuit should begin in the connecting head. With the sensor lengths usually used in slide bearings a difference of approx. 0,1 K results directly at the measuring resistor which represents a figure below the measuring accuracy of the instrument.

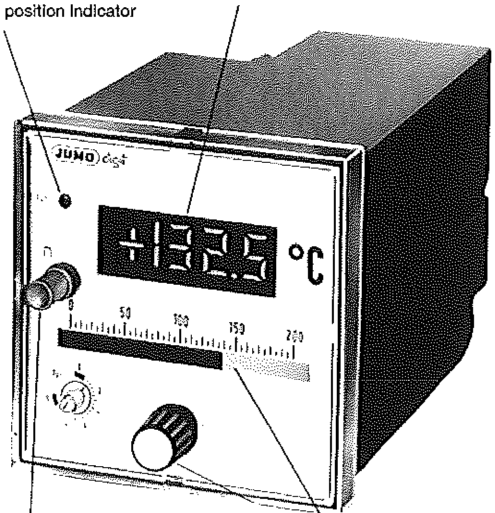

Figure 31 Regulator with digital display

Our scope of supply merely consists of the heat sensor which is supplied in the form of a flexible Pt 100 unit according to type specification RH 1016 (fig. 32), as a screw-in type resistance thermometer in accordance with type sheet RH 1015 (fig. 33) and as a sheathed resistance thermometer in accordance with type sheet RH 1036 (fig. 34).

These resistance thermometers are products which are manufactured specifically for our application by well-known German manufacturers. For this reason they are generally more suitable for the temperature measurement with slide bearings than standard products.

Display and regulating instruments do not normally form part of our scope of supply, since they are generally installed in a control panel which is central for the entire installation. However we shall be pleased to supply such units to special order.

Figure 32 Resistance thermometer Pt 100 flexible

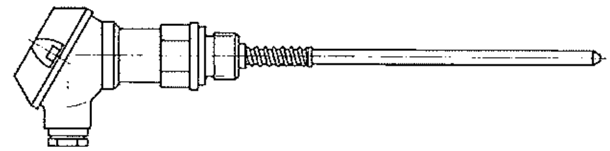

Figure 33 Screw-in type resistance thermometer Pt 100

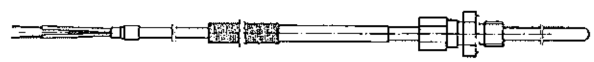

Figure 34 Sheathed resistance thermometer Pt 100

7. Heat Dissipation, Cooling

7.1 Radiation and Convection (Natural Cooling)

In many cases radiation and convection will be sufficient to limit the bearing temperature.

The temperature of the ambient air must be taken into account in the design stage. In most cases it will be impossible to protect the bearing from the ambient temperature. The ambient temperature has a direct influence on the heat-up of the bearing.

7.2. Forced-Air Convection Cooling

Forced air convection cooling is a better form of cooling. It is induced by the speed-up of air movement over the bearing housing by means of fans on the shaft or by separately installed blowers. Care must however be taken to see that no oil is drawn out of the seals by vacuum action. (Special seals or protections are available. See the section on „Seals".)

If, in the case of slide bearings with natural cooling or forced convection cooling, the atmospheric temperature increases by ΔT_{amb}, then the bearing temperature will also increase at the same time.

The temperature rise ΔT_B in the slide bearing can be roughly estimated with the aid of the approximation formula

$\Delta T_B = 0,7 \cdot \Delta T_{amb}$